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# Financial Analysis of Pruning Ponderosa Pine

Roger D. Fight, Natalie A. Bolon, and James M. Cahill





# Financial Analysis of Planning Forestry Plans

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## Abstract

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A recent lumber recovery study of pruned and unpruned ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) was used to project the financial return from pruning ponderosa pine in the Medford District of the Bureau of Land Management and in the Ochoco and Deschutes National Forests. The cost of pruning at which the investment would yield an expected 4-percent real rate of return was positive on sites where individual tree growth is fairly high, pruning is done as early as biologically possible given crown removal limitations, and the harvest is 30 to 70 years after pruning. The better situations showed a break-even cost of up to \$11 dollars per tree.

**Keywords:** Ponderosa pine, pruning, forest product value, product recovery, simulation, financial analysis.

## Summary

The financial return from pruning ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) in the Medford District of the Bureau of Land Management and in the Ochoco and Deschutes National Forests was analyzed. The cost of pruning at which the investment would yield an expected 4-percent real rate of return was positive on sites where individual tree growth is fairly high, pruning is done as early as biologically possible given crown removal limitations, and the harvest is 30 to 70 years after pruning. The better situations showed a break-even cost of up to \$11 dollars per tree. We believe that the case is made that pruning ponderosa pine in some circumstances is likely to be an investment yielding returns in excess of the 4-percent real rate desired from resource investments on Federal lands. Information and computer software are available that can be used by foresters, silviculturists, and analysts to determine under what circumstances pruning of ponderosa pine is a financially attractive investment on their lands.



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## Introduction

The moulding and millwork industry in the Western United States was built on clear wood from large, old ponderosa pine trees (*Pinus ponderosa* Dougl. ex Laws.) and still is dependent on that resource. With the trend toward harvesting younger timber, however, the quality of ponderosa pine lumber has been slowly declining for at least 20 years. The proportion of ponderosa pine lumber in Select, Moulding, and No. 1 Shop grades has declined from 20 percent to 13 percent since 1971. The proportion of lumber in No. 2 Shop and No. 3 Shop grades has increased from 23 percent to 39 percent since 1971 (Haynes and Fight, in press). During the same period, the real price of Select and Moulding grades increased by \$250 to \$700/MBF (million board feet) and the real price of dimension lumber declined slightly. Price projections for ponderosa pine lumber by Haynes and Fight (in press) point to additional increases in the real prices of high-quality lumber that exceed increases in the real prices of low-quality lumber. These trends could be accelerated dramatically by reductions in the harvest of older stands of ponderosa pine in National Forests and an abrupt shift to harvest of younger stands of ponderosa pine and to other species. Even if there were sufficient volume in younger stands of ponderosa pine to make up for the reduction in harvest of older stands, the quality of lumber would decline sharply. Product recovery from young-growth pine will consist mainly of the lower valued Common and Dimension lumber grades (Cahill 1991). The only way to significantly change that is through pruning.

A financial analysis of pruning coast Douglas-fir shows that there are many situations that could be expected to return substantially more than a 4-percent real rate of return (Fight and others 1987). Although the growth rate of coast Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco var. *menziesii*) trees on better sites substantially exceeds that of ponderosa pine trees on better sites, the price premiums for high-quality ponderosa pine lumber are expected to exceed those for Douglas-fir. Pruning ponderosa pine therefore seems to be a practice worthy of consideration because of the potential financial return. It also may be of interest because it would support employment in the moulding and millwork industry that is an important basic industry in many rural communities.

## Purpose

The main purpose of this paper is to present the results of financial analyses of pruning ponderosa pine in the Medford District of the Bureau of Land Management (BLM) and the Deschutes and Ochoco National Forests (NF). The second purpose is to present conclusions that can be drawn about the financial feasibility of pruning ponderosa pine and about priorities and regimes of pruning.

The results of these analyses are helpful in addressing the following questions about pruning ponderosa pine:

1. How does financial return compare for current stands of different productivity and stocking?
2. What is the best interval between pruning and harvest?
3. How important are future price assumptions in determining the financial return from pruning?

## Assumptions

The basis for estimating the increase in value of products from pruned logs was a lumber recovery study of pruned and unpruned logs (Cahill 1991). Cahill points out that the way the material was sawn by the mill probably resulted in a conservative estimate of the increase in value resulting from pruning. The value of products from the study



logs can be determined with any set of prices desired. Bolon and others (1992) describe a computer spreadsheet that can be used to estimate the financial return from pruning for different management regimes and assumed prices. It also describes in detail how the recovery study was used to estimate the value of pruned logs. The recovery study and our analysis evaluated pruning to a height of 17.5 feet to obtain a clear 16-foot log plus allowance for stump and trim. Prices used in this analysis are the projected prices for 2040 from Haynes and Fight (in press) in 1989 dollars.<sup>1</sup> Although Haynes and Fight give projections by decade to 2040, we use only those for 2040 because stands to be pruned will not be harvested before 2020 and the projected prices from 2020 to 2040 are virtually constant. For comparison, both current prices (Warren 1990-91) and future prices for lumber are shown in the following tabulation:

| Grade group and grade                        | Prices  |        |
|--|---------|--------|
|  | Current | Future |
|  | \$/MBF  |        |
| 4/4 Select and 1 Shop:                       |         |        |
| C Select and Better, 6-12 inches             | 1805    | 2206   |
| D Select, 12 inches                          | 1523    | 2130   |
| C and Better, 4 inches and D, 6-10 inches    | 1016    | 1408   |
| D Select, 4 inches                           | 740     | 935    |
| 1 Shop                                       | 438     | 583    |
| 5/4 and Thicker Moulding and Shops:          |         |        |
| Moulding and Better                          | 1265    | 1649   |
| 1 Shop                                       | 730     | 893    |
| 2 Shop                                       | 589     | 780    |
| 3 Shop                                       | 434     | 586    |
| Shopout                                      | 258     | 326    |
| 4/4 Commons and 8/4 Standard and Better:     |         |        |
| 2 Common, 12 inches                          | 532     | 705    |
| 2 Common, 4-10 inches                        | 331     | 506    |
| 3 Common, 6-12 inches, 8/4 dimension         | 261     | 367    |
| 3 Common, 4 inches and 4 Common, 4-12 inches | 189     | 297    |
| Low value:                                   |         |        |
| No. 3 and Utility                            | 155     | 262    |
| 5 Common and Economy                         | 105     | 153    |

Chips are valued at \$0.50 per cubic foot, and sawdust has no net value.

Our analysis took the silvicultural regime as fixed and analyzed the addition of pruning to the regime. The amount of clear wood in pruned logs is defined, as in the recovery study, as the difference in cubic volume of the butt log at time of pruning and time of harvest. We assumed that volume growth was not affected by pruning and that costs of stand management, harvesting, and manufacturing were unchanged except for the cost of pruning. We projected the increase in value of pruned logs without consideration of the cost of pruning. The resulting increase in present value provided an estimate of the break-even cost of pruning, or the maximum pruning cost that could be incurred that would still recover a real rate of return of 4 percent.

<sup>1</sup> Prices used in the analysis differ slightly because they were based on a preliminary producer price index for 1989.

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A study by Barrett (1968) estimates the loss in diameter growth resulting from different levels of crown removal. The growth loss depends on the crown ratio before pruning and the amount of crown removed. We assumed, based on Barrett's report, that trees with at least 80 percent live crown could be pruned to a height of 17.5 feet when they are at least 33 feet tall with a resulting loss in diameter growth small enough to be ignored (5 percent or less). For trees with 60 or 70 percent live crown, we assumed pruning to 17.5 feet could occur when they are at least 39 feet tall with loss in diameter growth small enough to be ignored (less than 3 percent for trees with 70 percent crown and less than 5 percent for trees with 60 percent crown). These assumptions were used with stand growth and yield information to project the increase in value of pruning for particular sites and regimes, except in one case from the Ochoco National Forest. The trees in this case were mixed conifers, pruned to 17.5 feet, and only 35 feet tall, which might result in a diameter growth loss of slightly more than 5 percent for trees with 70 percent or slightly less live crown.

## **Financial Analysis, Medford District**

### **Regimes and Yield Data**

Stock table data from the ORGANON growth and yield simulator (Hester and others 1989) for two sites and three regimes with moderate spacing were provided by the Medford District of BLM. References to site index (SI) in this case are to Hann-Scrivani 50-year site index (Hann and Scrivani 1987). Ponderosa pine sites of 55 (low site) and 80 (high site) were analyzed. The stocking after precommercial thinning was 150 trees per acre, and the tallest 70 trees were pruned in each regime. Regimes without commercial thinning for each site were analyzed, and one regime with two commercial thinnings was analyzed for SI 80.

### **Log and Tree Dimensions**

Appendix A shows the yield data input for the Medford District analysis for the above regimes. The ORGANON growth and yield simulator is an individual tree model. The diameters and heights for pruned trees at time of pruning and time of harvest are averages for the 70 tallest trees that are assumed to be the trees selected for pruning.

### **Other Key Assumptions**

The age of pruning for each regime was the earliest age ending in five that the trees could be pruned with an expected loss in diameter growth of less than 5 percent. Before pruning, the 70 tallest trees had crown ratios of 60 to 70 percent. Consequently, the necessary height needed before pruning could occur was 39 feet. Rotation ages of 60 to 100 years were considered for SI 55 and 50 to 90 years for SI 80. A 93-percent success rate was used to reflect 7-percent mortality in the pruned trees by harvest time.

## **Results**

Average diameter growth from time of pruning to harvest for the no thinning regimes was 1.6 to 2.0 inches per decade on SI 55 and 1.8 to 2.4 inches on SI 80 (fig. 1). Average diameter growth on the commercially thinned SI 80 stand was 2.0 to 2.5 inches per decade. These sites are some of the best sites in Oregon for growing ponderosa pine. The growth on these sites is significantly higher than that in the Ochoco or Deschutes National Forests. Pruned logs were expected to have 60-79 percent clear wood on SI 55 (depending on the regime and harvest age) and 69-84 percent clear wood on SI 80 (fig. 2). Commercially thinning the SI 80 site raised the clear wood percentage by 2 percent. Under the future price assumption, the value of the pruned butt logs increased almost linearly with time since pruning (fig. 3). The increase in value of the unpruned butt log resulted from the increase in diameter and volume, and the increase in value of the pruned butt log resulted from the increase in the amount of clear wood as well.



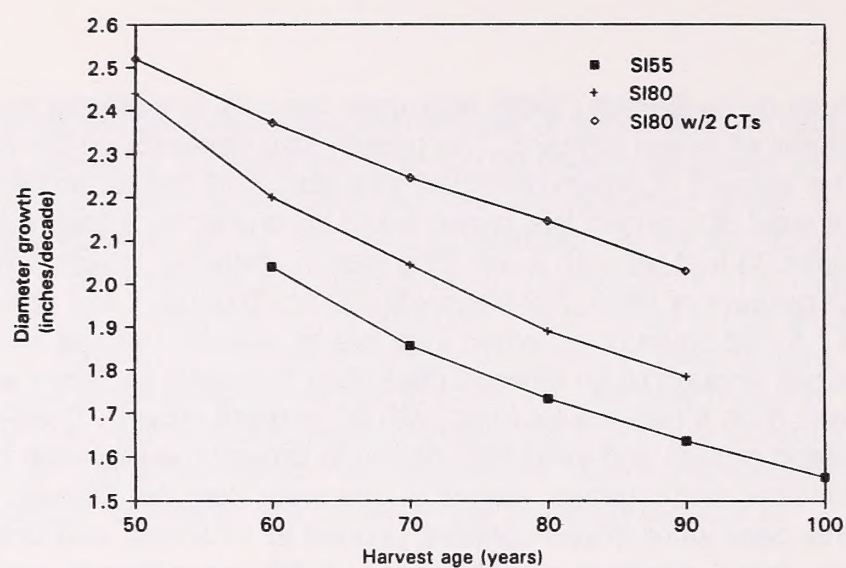


Figure 1—Average diameter growth (in inches per decade) from age of pruning to harvest for pruned ponderosa pine trees, BLM Medford District. The tallest 70 trees were pruned at age 35 on the 50-year site index 55 regime and at age 25 for both site index 80 regimes.

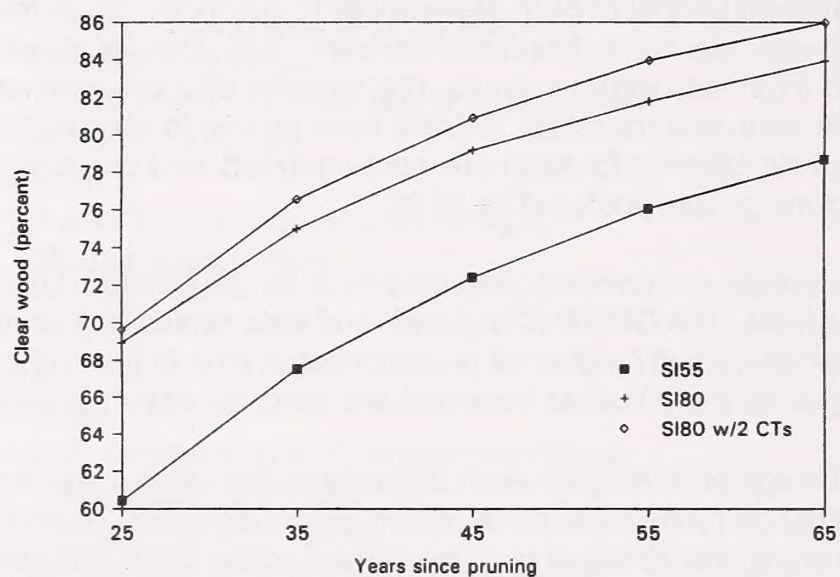


Figure 2—Clear wood in pruned ponderosa pine logs, BLM Medford District. The 50-year site index 55 regime was pruned at age 35, and both site index 80 regimes were pruned at age 25.

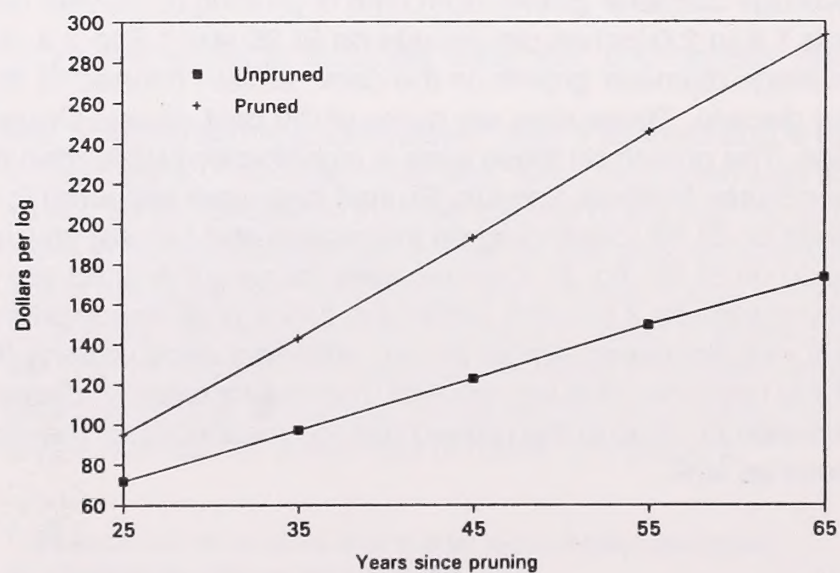


Figure 3—Future value of ponderosa pine butt logs, BLM Medford District. This 50-year site index 80 regime with thinning was pruned at age 25.



## **Financial Analysis, Ochoco National Forest**

### **Regimes and Yield Data**

### **Log and Tree Dimensions**

### **Other Key Assumptions**

### **Results**

Discounting future values at a 4-percent interest rate with a pruning cost of zero gives the break-even cost of pruning; that is, the amount that can be paid such that the investor just breaks even on the investment. Under the future price assumption, the break-even values were about \$3 to \$6 per tree on the low site and about \$7 to \$9 on the higher site without thinning and \$8 to \$11 with thinning (fig. 4). The greatest break-even cost at 4 percent interest for all BLM regimes was on the high site when thinned and harvested at age 70, 45 years after pruning. The higher site with thinning had faster growth, the same or smaller sized knotty core, more clear wood, and greater volumes than the unthinned regimes, thereby resulting in higher log values.

Yield data for the Ochoco NF are from the Blue Mountain variant of the prognosis growth and yield simulator (Wykoff and others 1982). References to SI are to Meyer's 100-year SI (Meyer 1938). We analyzed ponderosa pine SI 70 and mixed-conifer SI 80 with three stocking regimes on each. One regime had wide initial spacing with one commercial thin, another had moderate spacing with two commercial thins, and a third had narrow spacing with four commercial thins.

Appendix B shows the yield data used in the Ochoco NF analysis under the above regimes. Although the prognosis growth and yield simulator is an individual tree model, Ochoco NF personnel suggested that the average stand diameter at time of pruning be used for the diameter of the pruned trees. If in fact the trees selected for pruning are the largest trees in the stand, this assumption results in an overestimate of the amount of clear wood and the return from pruning. In all cases, all crop trees are assumed to be pruned so that the average stand diameter at time of harvest is the same as the average diameter of the pruned trees. The number of crop trees differs with the assumed rotation age.

The age of pruning for each regime was the earliest age ending in zero that the trees could be pruned with an expected loss in diameter growth of less than 5 percent with the one exception: the regimes on SI 80 were pruned at age 40 when the average stand height was 35 feet. This violates the general rule a bit, but by age 50 the trees would be about 45 feet tall. Rotation ages of 70 to 120 years were considered for the regimes on the mixed-conifer sites and 80 to 120 years for the ponderosa pine sites. A 90-percent success rate was used to reflect 10-percent mortality in the pruned trees by harvest time.

Average diameter growth from time of pruning to harvest was 1.3 to 1.6 inches per decade on SI 70 and 1.4 to 1.8 inches on SI 80 (figs. 5 and 6). The irregularities in the trends in decadal growth occur because the growth rate is the average for the entire stand, and the average stand diameter increases when the stand is thinned from below. Pruned logs were expected to have 60-83 percent clear wood on SI 70 (depending on the regime and harvest age) and 70-90 percent clear wood on SI 80 (figs. 7 and 8). Under the future price assumption, the value of the pruned butt logs increased in a generally linear fashion with time since pruning (fig. 9).

Under the future price assumption the break-even costs were about \$0 to \$3 on the ponderosa pine sites and about \$1 to \$4 for the mixed-conifer sites (figs. 10 and 11). A plateau occurs for both sites about 40 years after pruning. In general, the wide initial spacing tended to show greater break-even costs. The greatest break-even cost at a 4-percent real interest rate for both sites was for the wide initial spacing with harvest 50 years after pruning. The mixed-conifer sites generally showed higher break-even costs than the ponderosa pine sites. The mixed-conifer site had faster growth, a smaller knotty core, more clear wood, and greater volumes than the ponderosa pine site—all reflected in the greater log values.



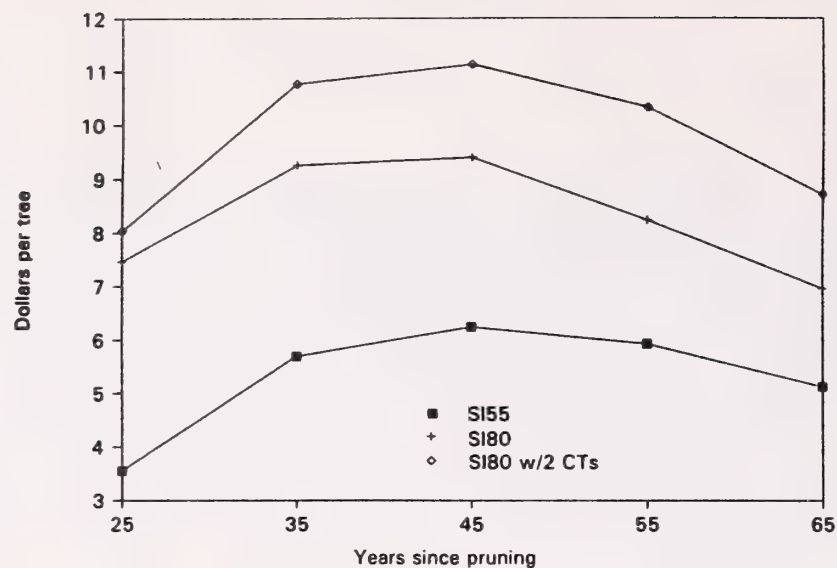


Figure 4—Break-even cost of pruning, under the future price assumption and a 4-percent real interest rate, BLM Medford District ponderosa pine regimes. The 50-year site index 55 regime was pruned at age 35, and both site index 80 regimes were pruned at age 25.

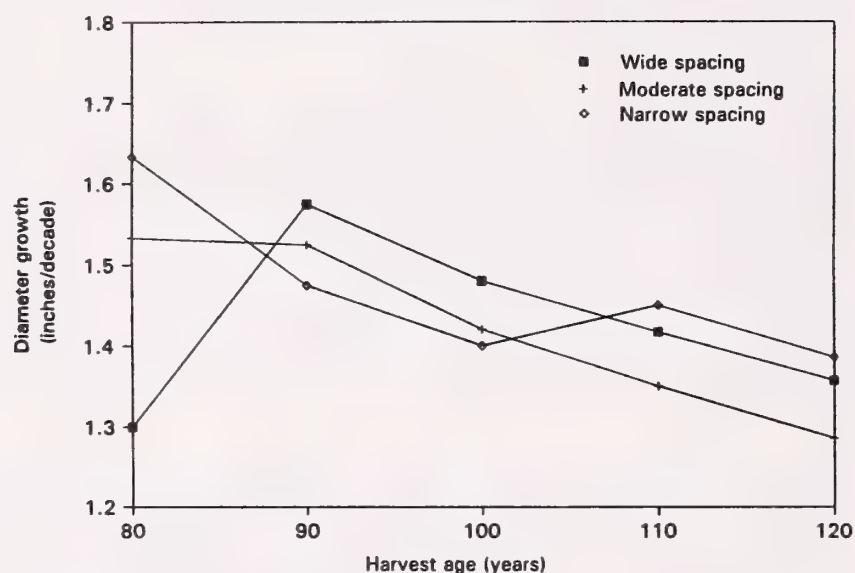


Figure 5—Average diameter growth (in inches per decade) from age of pruning to harvest for pruned ponderosa pine trees, Ochoco National Forest. These 100-year site index 70 regimes were pruned at age 50.

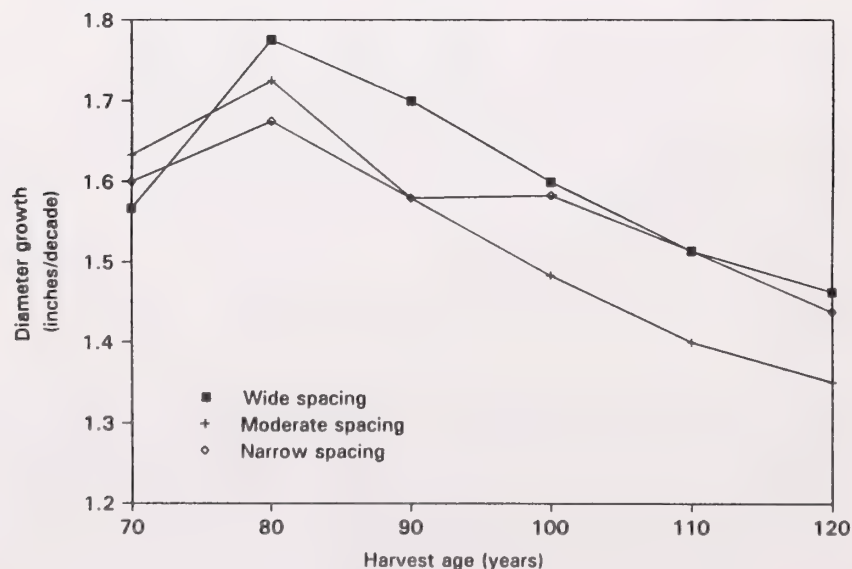


Figure 6—Average diameter growth (in inches per decade) from age of pruning to harvest for pruned ponderosa pine trees, Ochoco National Forest. These mixed-conifer 100-year site index 80 regimes were pruned at age 40.



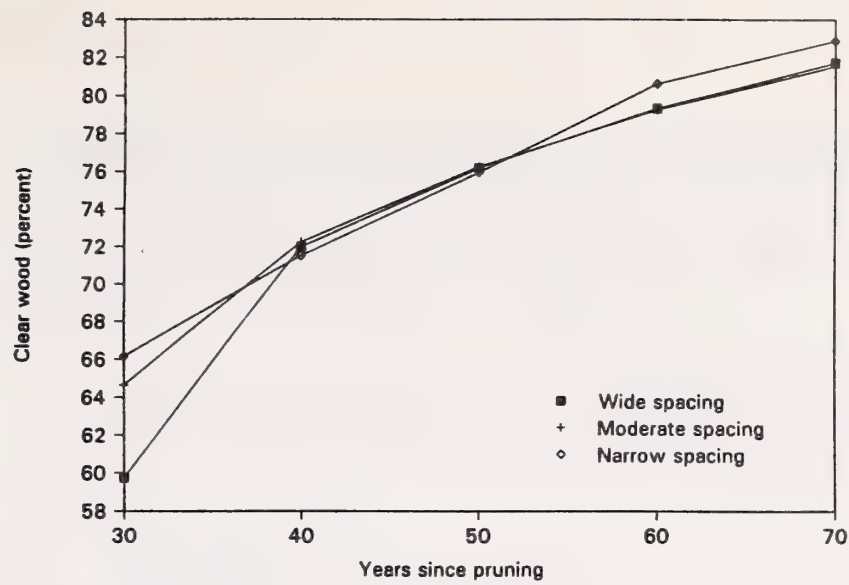


Figure 7—Clear wood in pruned ponderosa pine logs, Ochoco National Forest. These 100-year site index 70 regimes were pruned at age 50.

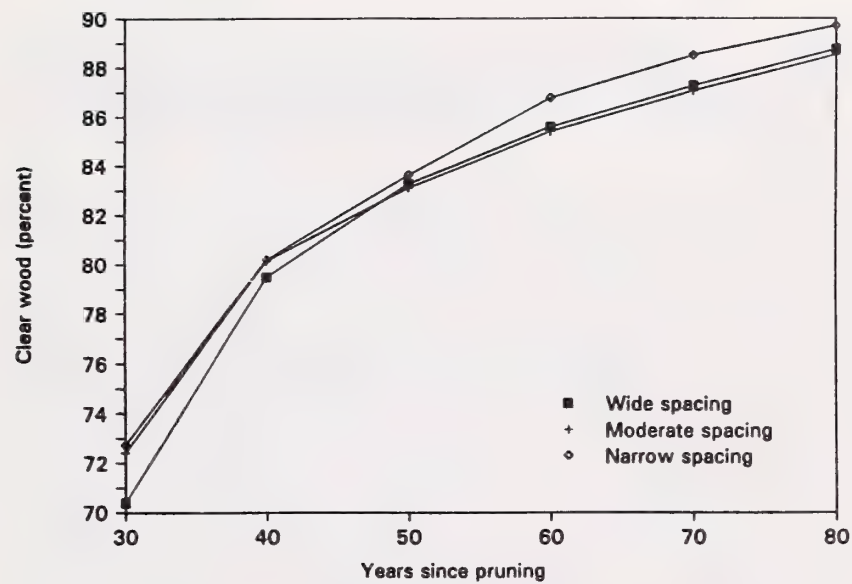


Figure 8—Clear wood in pruned ponderosa pine logs, Ochoco National Forest. These mixed-conifer 100-year site index 80 regimes were pruned at age 40.

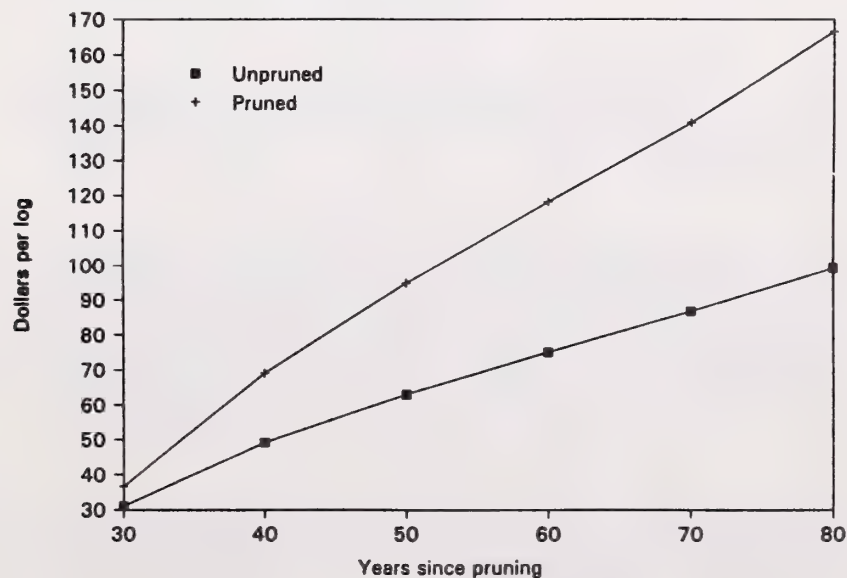


Figure 9—Future value of ponderosa pine butt logs, Ochoco National Forest. This mixed-conifer 100-year site index 80 wide-spacing regime was pruned at age 40.



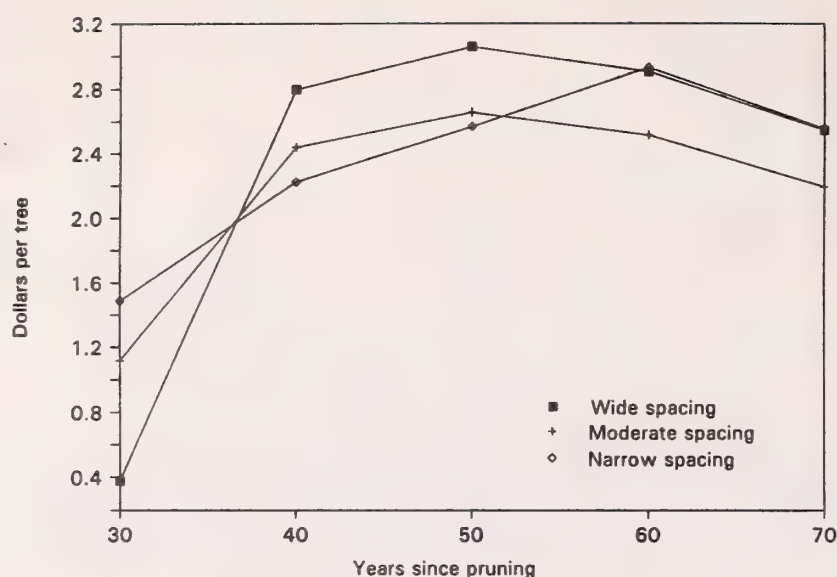


Figure 10—Break-even cost of pruning, under the future price assumption and a 4-percent real interest rate, Ochoco National Forest ponderosa pine 100-year site index 70 regimes. These regimes were pruned at age 50.

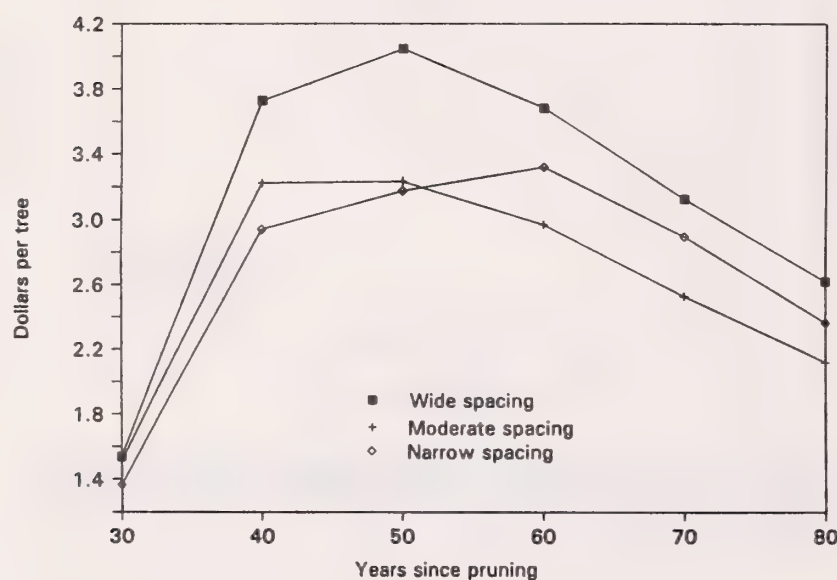


Figure 11—Break-even cost of pruning, under the future price assumption and a 4-percent real interest rate, Ochoco National Forest ponderosa pine in a mixed-conifer 100-year site index 80 stand. These regimes were pruned at age 40.

## Financial Analysis, Deschutes National Forest

### Regimes and Yield Data

### Log and Tree Dimensions

Yield data for the Deschutes NF are from the SORNAC variant of the prognosis growth and yield simulator (Wykoff and others 1982). Reference to SI are to Meyer's 100-year SI (Meyer 1938). We analyzed ponderosa pine SIs 75 and 79 and a mixed-conifer SI 90. Two regimes for each site were analyzed: a regime with no thinnings and a regime with precommercial thinning and three commercial thinnings.

Appendix C shows the yield data used in the Deschutes NF analysis under the above regimes. Like the Ochoco analysis, this analysis used the simplifying assumption that the average stand diameter at time of pruning be used for the diameter of the pruned trees.



## **Other Key Assumptions**

The age of pruning for each regime was the earliest age ending in five that the trees could be pruned with an expected loss in diameter growth of less than 5 percent. Rotation ages of 75 to 115 years were considered for the ponderosa pine sites and 75 to 125 for the mixed-conifer site. A 90-percent success rate was used to reflect 10-percent mortality in the pruned trees by harvest time.

## **Results**

Average diameter growth from time of pruning to harvest was 1.2 to 1.5 inches per decade on unthinned stands and 1.5 to 1.7 inches per decade on thinned stands (figs. 12 and 13). The irregularities in the trends in decadal growth result because the growth rate is the average for the entire stand, and the average stand diameter increases when the stand is thinned from below. The growth on the mixed-conifer sites closely paralleled that on both ponderosa pine sites because the stocking after precommercial thinning was higher for the mixed-conifer sites. The percentage of clear wood was somewhat higher in the mixed-conifer stands (figs. 14 and 15). Under the future price assumption, the value of the pruned butt logs increased in a generally linear fashion with time since pruning (fig. 16).

Under the future price assumption, the break-even values were about \$1 to \$3 on the unthinned stands and about \$2 to \$5 for the thinned stands (figs. 17 and 18). Whether the regime included thinning or not was more important than site quality. This resulted because the increase in growth of clear wood with thinning was large enough to offset the differences in growth related to site quality. Under the future price assumption, the ponderosa pine stands on SI 75 with thinning resulted in the greatest present value of all the Deschutes NF management regimes. We expected that pruning the mixed-conifer stand on the better site (SI 90) in conjunction with commercial thinning would result in the greatest break-even cost, but this was not the case. The reason that the SI 75 pine site had the greatest value becomes apparent when stocking densities are considered. Precommercial thinning on the mixed-conifer SI 90 site reduced the stocking to about 300 trees per acre whether or not the regimes were to be thinned later. Both pine sites were precommercially thinned to about 150 trees per acre for no thinning regimes, and if thinning was to occur, to about 200 on the SI 79 and 180 for SI 75. The SI 75 pine site had fewer trees, which were able to put on more diameter growth.

## **Discussion**

### **Comparisons of Site Quality and Stocking**

What do these results tell us about how the financial return from pruning compares on stands of different site productivity and stocking? Financial returns from pruning depend on the growth rates of individual pruned trees rather than the growth rates of stands. In general, that means that regimes achieving faster growth on individual trees will be more attractive for pruning. The greatest break-even cost that we found was on the highly productive sites of the Medford District with regimes that included thinning. For the range of site indices considered for the two National Forests, stocking was generally more important than site in determining the break-even cost. This suggests that in practice we should look to lightly stocked stands and stands that will be thinned as first priority candidate stands for pruning. If pruning is to be considered for application to future managed stands, it is desirable to do a broad analysis of management regimes to see what regime of stocking with pruning would give the best overall financial return.

### **Years Between Pruning and Harvest**

What interval between pruning and harvest will produce the greatest break-even cost? On the National Forests, 50 years after pruning generally gave the greatest expected financial return. Usually, there is a plateau of at least 10 years on either side of the optimal that provides considerable flexibility in harvesting with only a small reduction in financial return. On the more productive BLM sites, the best interval was 45 years.



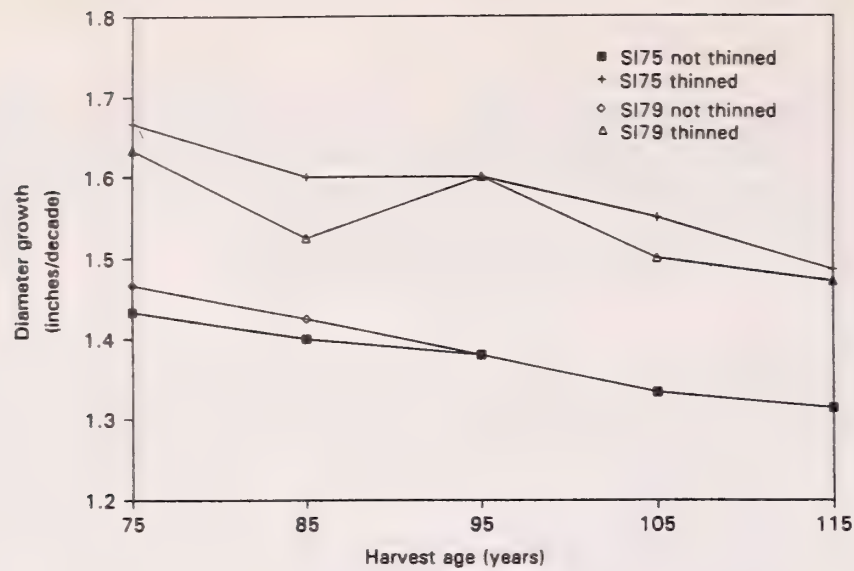


Figure 12—Average diameter growth (in inches per decade) from age of pruning to harvest for pruned ponderosa pine trees, Deschutes National Forest. These 100-year site index 75 and 79 regimes were pruned at age 45.

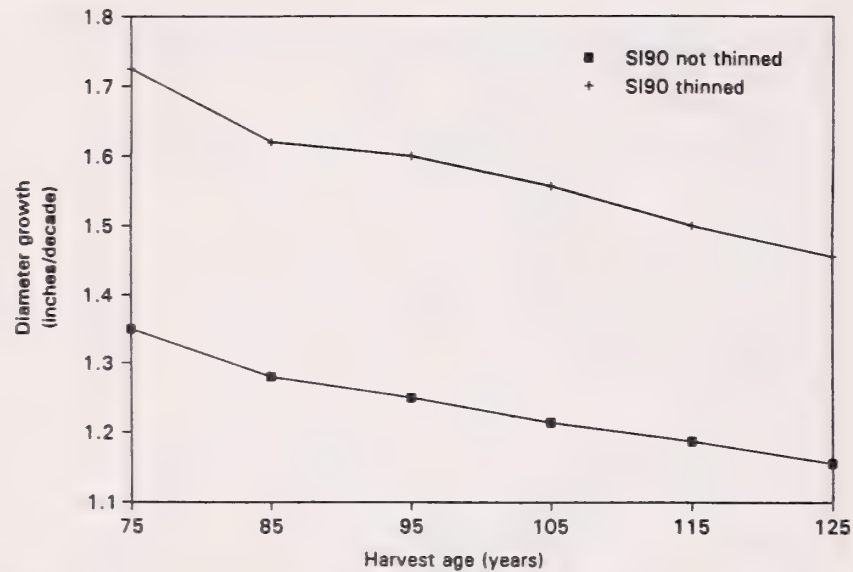


Figure 13—Average diameter growth (in inches per decade) from age of pruning to harvest for pruned ponderosa pine trees, Deschutes National Forest. These mixed-conifer 100-year site index 90 regimes were pruned at age 35.

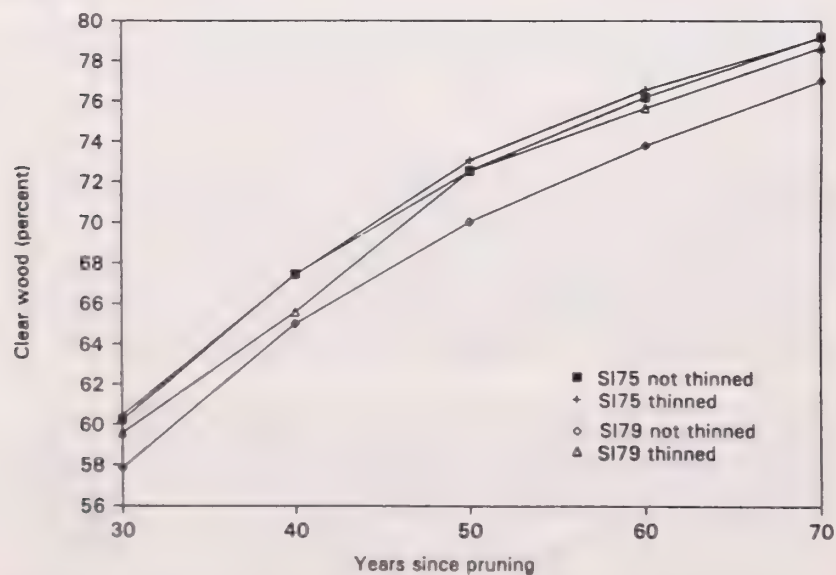


Figure 14—Clear wood in pruned ponderosa pine logs, Deschutes National Forest. These 100-year site index 75 and 79 regimes were pruned at age 45.



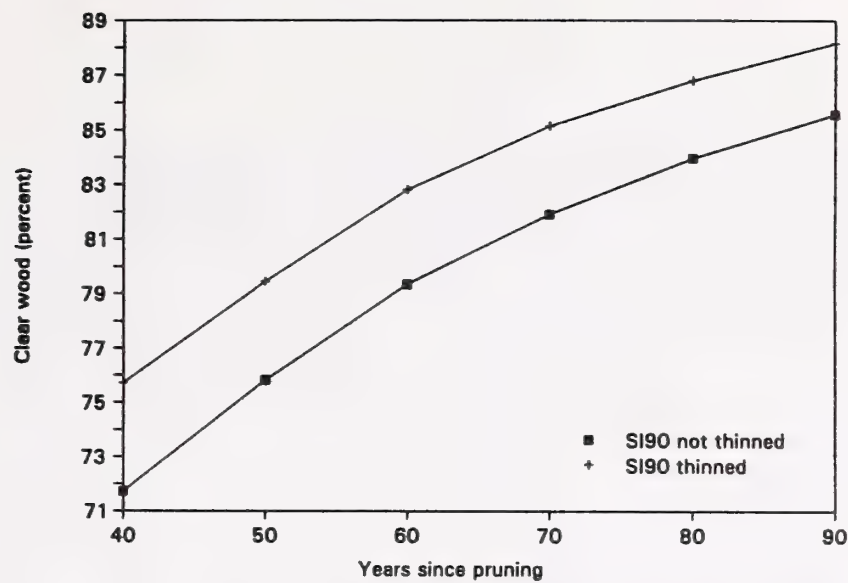


Figure 15—Clear wood in pruned ponderosa pine logs, Deschutes National Forest. These mixed-conifer 100-year site index 90 regimes were pruned at age 35.

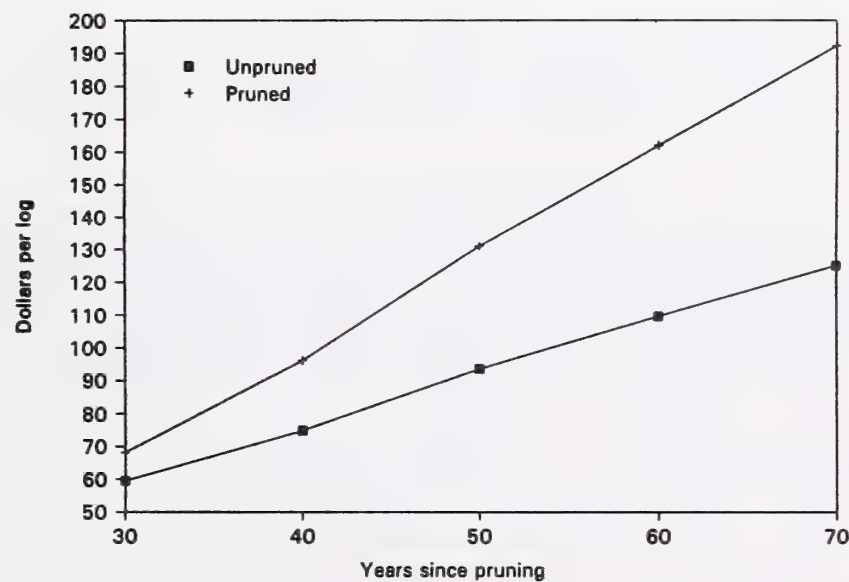


Figure 16—Future value of ponderosa pine butt logs, Deschutes National Forest. This 100-year site index 75 thinned regime was pruned at age 45.

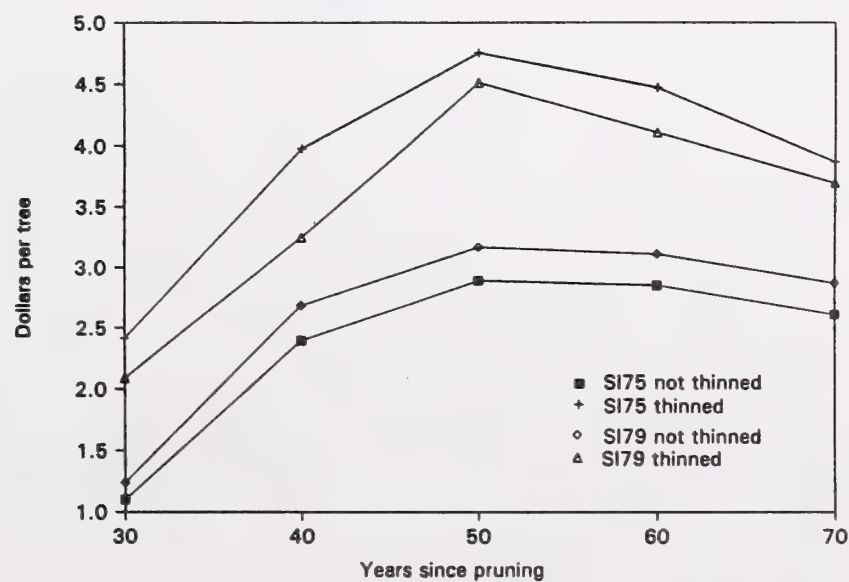


Figure 17—Break-even cost of pruning, under the future price assumption and a 4-percent real interest rate, Deschutes National Forest ponderosa pine 100-year site index 75 and 79 regimes. These regimes were pruned at age 45.



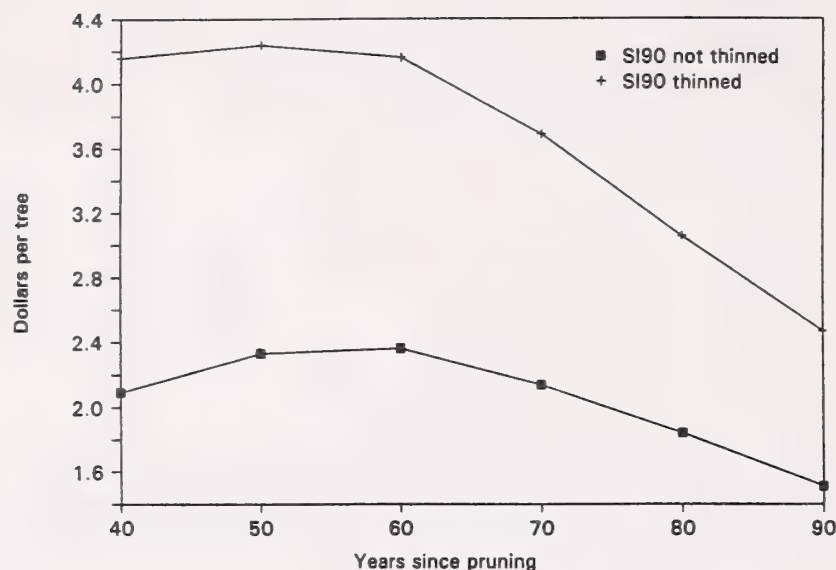


Figure 18—Break-even cost of pruning, under the future price assumption and a 4-percent real interest rate, Deschutes National Forest ponderosa pine in a mixed-conifer 100-year site index 90 stand. These regimes were pruned at age 35.

### Sensitivity of Financial Return to Price Assumption

Are large increases in future prices required to make the financial return to pruning attractive? Because all the pruning regimes are affected similarly by different sets of price assumptions, a good way to judge the importance of the price assumptions is to look at the effect of many sets of prices on one regime. The Medford District SI 80 regime with commercial thinnings gave the best return to pruning. Figure 19 shows this regime analyzed with real prices of lumber over the past 20 years and for prices projected to 2040 (Haynes and Fight, in press). Pruning of ponderosa pine up to 17.5 feet in one entry (one lift) is being contracted for \$1 to \$3 per tree. If the landowner captures in stumpage most of the increase in value, the regime in figure 19 would be an attractive investment under any prices that have occurred during the past 20 years. The 2040 price assumption increases the value of products from pruned logs by about 50 percent above the 1990 prices, but by only about 10 percent over the previous prices most favorable to pruning (1987). The effect of these prices on other regimes is to change the break-even cost in very nearly the same proportion as for the best regime.

What about the possibility of decreases in the price of high-quality lumber that might result from substitution of clear radiata pine (*Pinus radiata* D. Don) or substitution of composite materials? A thorough discussion of this issue is beyond the scope of this paper, but a couple points may be of interest. At least since 1971, the premiums for high-quality grades of lumber have tended to increase (Haynes and Fight, in press). Substitution always has been a possibility and has occurred to some extent continuously as conditions favored it. Even though this has occurred, substitutions for high-quality lumber have not been sufficient to reverse long-term trends of increasing premiums for high-quality wood. Although the projected prices are derived from national-level projections of wood products markets that recognize to some degree the possibility of substitutions within broad product categories (Haynes 1990), the price premiums among grades are based primarily on projections of trends in prices and volumes by grade.

### Financial Return From Pruning Douglas-fir

In general, the financial return from pruning ponderosa pine seems to be less than that from pruning Douglas-fir. Although prices for clear ponderosa pine generally exceed those for clear Douglas-fir, the greater diameter growth rates for Douglas-fir more than



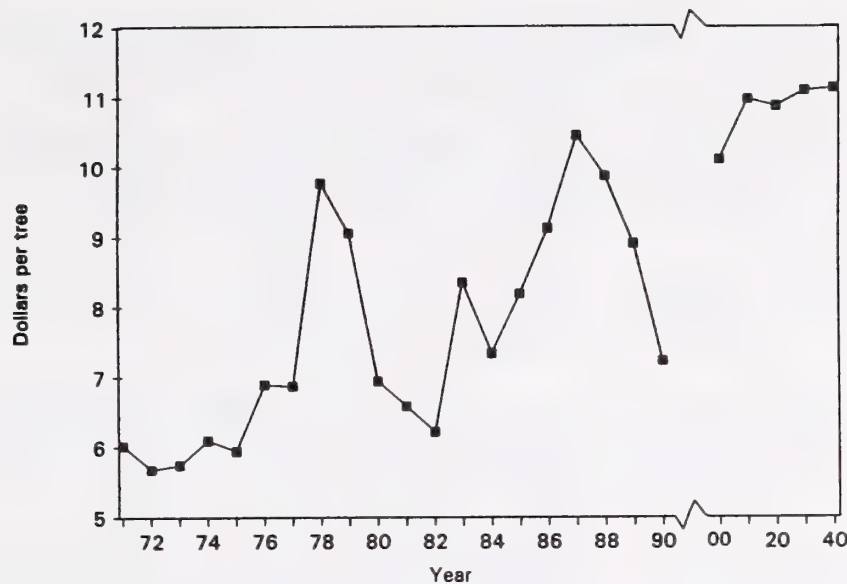


Figure 19—Break-even cost of pruning with historical and projected real prices and a 4-percent real interest rate, BLM Medford District. This ponderosa pine 100-year site index 80 with thinning regime was pruned at age 25.

offset the price difference. On the other hand, the differences in appearance between currently available clear wood and clear wood from pruned young-growth trees available in the future are more significant in Douglas-fir than in ponderosa pine. It is likely that the existing moulding and millwork industry that uses ponderosa pine will readily accept clear wood from pruned ponderosa pine. Much of the clear Douglas-fir goes into the export market where its acceptance is less certain.

## Conclusion

We believe that the case is made that pruning ponderosa pine in some circumstances is likely to be an investment yielding returns in excess of the 4-percent real rate desired from resource investments on Federal lands. Information and computer software are available that can be used by foresters, silviculturists, and analysts to determine under what circumstances pruning of ponderosa pine is a financially attractive investment on their lands (Bolon and others 1992).

## Acknowledgments

We thank Robert Pierle and Robert Lewis, Medford District, Bureau of Land Management; Don Wood, Ochoco NF; and Jo Booser, Deschutes NF; for compiling yield data and cooperating in the design of the analyses.

## Metric Equivalents

1 inch = 2.54 centimeters  
 1 foot = 0.305 meter  
 1 cubic foot = 0.028 cubic meter  
 1 acre = 0.4047 hectare



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## Appendix A

### Yield Data, Medford District

The BLM Medford District yield data as used in the analysis:

| AGE1  | AGE2 | DBH1 | DBH2 | HEIGHT1 | HEIGHT2 | #TREES | SUCCESS |
|---|------|------|------|---------|---------|--------|---------|
| BLM MEDFORD DISTRICT-USING TOP 70 PRUNED TREES-NO TRT-HS SI55 |      |      |      |         |         |        |         |
| 35  | 50   | 11.9 | 15.2 | 41      | 56      | 70     | 0.93    |
| 35  | 60   | 11.9 | 17.0 | 41      | 65      | 70     | 0.93    |
| 35  | 70   | 11.9 | 18.4 | 41      | 73      | 70     | 0.93    |
| 35  | 80   | 11.9 | 19.7 | 41      | 80      | 70     | 0.93    |
| 35  | 90   | 11.9 | 20.9 | 41      | 87      | 70     | 0.93    |
| 35  | 100  | 11.9 | 22.0 | 41      | 92      | 70     | 0.93    |
| SI80 NO TRT   |      |      |      |         |         |        |         |
| 25  | 40   | 10.9 | 15.0 | 41      | 65      | 70     | 0.93    |
| 25  | 50   | 10.9 | 17.0 | 41      | 80      | 70     | 0.93    |
| 25  | 60   | 10.9 | 18.6 | 41      | 92      | 70     | 0.93    |
| 25  | 70   | 10.9 | 20.1 | 41      | 104     | 70     | 0.93    |
| 25  | 80   | 10.9 | 21.3 | 41      | 113     | 70     | 0.93    |
| 25  | 90   | 10.9 | 22.5 | 41      | 122     | 70     | 0.93    |
| SI80 w/2 CTs  |      |      |      |         |         |        |         |
| 25  | 45   | 10.9 | 16.1 | 41      | 73      | 70     | 0.93    |
| 25  | 50   | 10.9 | 17.2 | 41      | 80      | 70     | 0.93    |
| 25  | 60   | 10.9 | 19.2 | 41      | 93      | 70     | 0.93    |
| 25  | 70   | 10.9 | 21.0 | 41      | 104     | 70     | 0.93    |
| 25  | 80   | 10.9 | 22.7 | 41      | 114     | 70     | 0.93    |
| 25  | 90   | 10.9 | 24.1 | 41      | 122     | 70     | 0.93    |



## Appendix B

### Yield Data, Ochoco National Forest

| AGE1  | AGE2 | DBH1 | DBH2 | HEIGHT1 | HEIGHT2 | #TREES | SUCCESS |
|---|------|------|------|---------|---------|--------|---------|
| OCHOCO NF MIXED-CONIFER SI80 REGIMES 1-3-PRUNE @ 40 |      |      |      |         |         |        |         |
| Regime 1-Wide Spacing w/1 CT                        |      |      |      |         |         |        |         |
| 40  | 70   | 8.0  | 12.7 | 35      | 61      | 89     | 0.90    |
| 40  | 80   | 8.0  | 15.1 | 35      | 66      | 49     | 0.90    |
| 40  | 90   | 8.0  | 16.5 | 35      | 72      | 49     | 0.90    |
| 40  | 100  | 8.0  | 17.6 | 35      | 77      | 49     | 0.90    |
| 40  | 110  | 8.0  | 18.6 | 35      | 81      | 49     | 0.90    |
| Regime 2-Mod Spacing w/2 CTs                        |      |      |      |         |         |        |         |
| 40  | 70   | 7.5  | 12.4 | 35      | 60      | 109    | 0.90    |
| 40  | 80   | 7.5  | 14.4 | 35      | 66      | 58     | 0.90    |
| 40  | 90   | 7.5  | 15.4 | 35      | 72      | 58     | 0.90    |
| 40  | 100  | 7.5  | 16.4 | 35      | 77      | 58     | 0.90    |
| 40  | 110  | 7.5  | 17.3 | 35      | 81      | 58     | 0.90    |
| 40  | 120  | 7.5  | 18.3 | 35      | 84      | 58     | 0.90    |
| Regime 3-Narrow Spacing w/3 CTs                     |      |      |      |         |         |        |         |
| 40  | 70   | 7.3  | 12.1 | 35      | 61      | 124    | 0.90    |
| 40  | 80   | 7.3  | 14.0 | 35      | 67      | 67     | 0.90    |
| 40  | 90   | 7.3  | 15.2 | 35      | 73      | 67     | 0.90    |
| 40  | 100  | 7.3  | 16.8 | 35      | 77      | 43     | 0.90    |
| 40  | 110  | 7.3  | 17.9 | 35      | 81      | 43     | 0.90    |
| 40  | 120  | 7.3  | 18.8 | 35      | 85      | 43     | 0.90    |
| PPINE SI70-PRUNE @ 50                               |      |      |      |         |         |        |         |
| Regime 4-Wide Spacing w/1 CT                        |      |      |      |         |         |        |         |
| 50  | 70   | 9.1  | 12.0 | 39      | 53      | 67     | 0.90    |
| 50  | 80   | 9.1  | 13.0 | 39      | 58      | 65     | 0.90    |
| 50  | 90   | 9.1  | 15.4 | 39      | 63      | 35     | 0.90    |
| 50  | 100  | 9.1  | 16.5 | 39      | 68      | 35     | 0.90    |
| 50  | 110  | 9.1  | 17.6 | 39      | 71      | 35     | 0.90    |
| 50  | 120  | 9.1  | 18.6 | 39      | 74      | 35     | 0.90    |
| Regime 5-Mod Spacing w/2 CTs                        |      |      |      |         |         |        |         |
| 50  | 70   | 8.7  | 12.0 | 39      | 53      | 71     | 0.90    |
| 50  | 80   | 8.7  | 13.3 | 39      | 58      | 71     | 0.90    |
| 50  | 90   | 8.7  | 14.8 | 39      | 63      | 43     | 0.90    |
| 50  | 100  | 8.7  | 15.8 | 39      | 68      | 43     | 0.90    |
| 50  | 110  | 8.7  | 16.8 | 39      | 71      | 43     | 0.90    |
| 50  | 120  | 8.7  | 17.7 | 39      | 74      | 43     | 0.90    |
| 50  | 130  | 8.7  | 18.6 | 39      | 76      | 43     | 0.90    |
| Regime 6-Narrow Spacing w/4 CTs                     |      |      |      |         |         |        |         |
| 50  | 70   | 8.7  | 11.4 | 39      | 52      | 115    | 0.90    |
| 50  | 80   | 8.7  | 13.6 | 39      | 58      | 61     | 0.90    |
| 50  | 90   | 8.7  | 14.6 | 39      | 63      | 61     | 0.90    |
| 50  | 100  | 8.7  | 15.7 | 39      | 68      | 61     | 0.90    |
| 50  | 110  | 8.7  | 17.4 | 39      | 71      | 33     | 0.90    |
| 50  | 120  | 8.7  | 18.4 | 39      | 74      | 33     | 0.90    |



## Appendix C

### Yield Data, Deschutes National Forest

| AGE1                                   | AGE2 | DBH1 | DBH2 | HEIGHT1 | HEIGHT2 | #TREES | SUCCESS |
|--|------|------|------|---------|---------|--------|---------|
| Deschutes NF-PPine SI75-PRUNE @ 45     |      |      |      |         |         |        |         |
| No TRT                                 |      |      |      |         |         |        |         |
| 45                                     | 75   | 10.1 | 14.4 | 39      | 60      | 115    | 0.90    |
| 45                                     | 85   | 10.1 | 15.7 | 39      | 65      | 115    | 0.90    |
| 45                                     | 95   | 10.1 | 17.0 | 39      | 68      | 92     | 0.90    |
| 45                                     | 105  | 10.1 | 18.1 | 39      | 72      | 92     | 0.90    |
| 45                                     | 115  | 10.1 | 19.3 | 39      | 74      | 73     | 0.90    |
| Precommercial thinning (PCT) and 3 CTs |      |      |      |         |         |        |         |
| 45                                     | 75   | 11.6 | 16.6 | 40      | 62      | 54     | 0.90    |
| 45                                     | 85   | 11.6 | 18.0 | 40      | 68      | 54     | 0.90    |
| 45                                     | 95   | 11.6 | 19.6 | 40      | 73      | 37     | 0.90    |
| 45                                     | 105  | 11.6 | 20.9 | 40      | 76      | 37     | 0.90    |
| 45                                     | 115  | 11.6 | 22.0 | 40      | 80      | 37     | 0.90    |
| PPine SI79-PRUNE @ 45                  |      |      |      |         |         |        |         |
| No TRT                                 |      |      |      |         |         |        |         |
| 45                                     | 75   | 11.0 | 15.4 | 42      | 64      | 119    | 0.90    |
| 45                                     | 85   | 11.0 | 16.7 | 42      | 69      | 119    | 0.90    |
| 45                                     | 95   | 11.0 | 17.9 | 42      | 73      | 96     | 0.90    |
| 45                                     | 105  | 11.0 | 19.0 | 42      | 77      | 96     | 0.90    |
| 45                                     | 115  | 11.0 | 20.2 | 42      | 80      | 77     | 0.90    |
| PCT and 3 CTs                          |      |      |      |         |         |        |         |
| 45                                     | 75   | 11.4 | 16.3 | 42      | 64      | 73     | 0.90    |
| 45                                     | 85   | 11.4 | 17.5 | 42      | 68      | 73     | 0.90    |
| 45                                     | 95   | 11.4 | 19.4 | 42      | 73      | 49     | 0.90    |
| 45                                     | 105  | 11.4 | 20.4 | 42      | 78      | 49     | 0.90    |
| 45                                     | 115  | 11.4 | 21.7 | 42      | 81      | 49     | 0.90    |
| Mixed-conifer SI90-PRUNE @ 35          |      |      |      |         |         |        |         |
| No TRT                                 |      |      |      |         |         |        |         |
| 35                                     | 75   | 8.4  | 13.8 | 40      | 76      | 243    | 0.90    |
| 35                                     | 85   | 8.4  | 14.8 | 40      | 81      | 243    | 0.90    |
| 35                                     | 95   | 8.4  | 15.9 | 40      | 86      | 203    | 0.90    |
| 35                                     | 105  | 8.4  | 16.9 | 40      | 90      | 203    | 0.90    |
| 35                                     | 115  | 8.4  | 17.9 | 40      | 93      | 170    | 0.90    |
| 35                                     | 125  | 8.4  | 18.8 | 40      | 96      | 170    | 0.90    |
| PCT and 3 CTs                          |      |      |      |         |         |        |         |
| 35                                     | 75   | 9.0  | 15.9 | 39      | 74      | 102    | 0.90    |
| 35                                     | 85   | 9.0  | 17.1 | 39      | 80      | 102    | 0.90    |
| 35                                     | 95   | 9.0  | 18.6 | 39      | 84      | 65     | 0.90    |
| 35                                     | 105  | 9.0  | 19.9 | 39      | 88      | 65     | 0.90    |
| 35                                     | 115  | 9.0  | 21.0 | 39      | 92      | 65     | 0.90    |
| 35                                     | 125  | 9.0  | 22.1 | 39      | 95      | 65     | 0.90    |







**Fight, Roger D.; Bolon, Natalie A.; Cahill, James M. 1992.** Financial analysis of pruning ponderosa pine. Res. Pap. PNW-RP-449. Portland, OR: U.S. Department of Agriculture, Forest Service, Pacific Northwest Research Station. 17 p.

A recent lumber recovery study of pruned and unpruned ponderosa pine (*Pinus ponderosa* Dougl. ex Laws.) was used to project the financial return from pruning ponderosa pine in the Medford District of the Bureau of Land Management and in the Ochoco and Deschutes National Forests. The cost of pruning at which the investment would yield an expected 4-percent real rate of return was positive on sites where individual tree growth is fairly high, pruning is done as early as biologically possible given crown removal limitations, and the harvest is 30 to 70 years after pruning. The better situations showed a break-even cost of up to \$11 dollars per tree.

**Keywords:** Ponderosa pine, pruning, forest product value, product recovery, simulation, financial analysis.

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